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DRAWINGS ATTACHED

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(54) TUBULAR MEMBER

(71) We, CLEVEPAK CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America of 6201 Barberton Avenue, Cleveland, Ohio 44102, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

With many containers, especially corrugated or solid fibre boxes, the side walls often require reinforcement so that the container can withstand certain stresses and strains. For example, when containers are stacked one upon another and the containers rather than the contents must provide the support, the walls of the lowermost containers in a stack must bear substantial forces which tend to deform the side walls. If the walls are permitted to deform significantly, any fragile contents may suffer damage.

To increase rigidity, wooden corner posts, corrugated or fibrous posts or cylindrical tubes have been inserted in containers to provide reinforcement along particular coordinates. Wooden posts are becoming more costly and interfere in conventional scrap carton recycling, wherein containers are shredded for return to paper makers. Corrugated and fibrous posts are often inadequate in strength, when large stresses are to be placed upon containers in which they are the primary reinforcement. This is because the typical shaping cuts reduce their load-bearing capacity. Cylindrical tubes, besides occupying peripheral storage space, contact containers only tangentially along the tube length and this minimal surface-to-surface contact provides little abutment strength even when the tube is adhered to the container walls for reinforcing a container in a direction transverse to the axis of such tubes.

In accordance with the invention, an elongate stiff tubular supporting member has a unitary wall including at least one layer of material extending jointlessly around its whole periphery, the wall being substantially triangular in cross section and incorporating elongate strength-giving components aligned predominately longitudinally of the member.

Such members may be used in many applications for example as short vertical legs of a carton, or as horizontal skids for a pallet. Their prime use, however, is as reinforcing supports or columns for the walls of corrugated or other containers and, when stuck into the corners of rectangular box-like containers, they integrate with the container walls to provide both axial and transverse strength against carton deformation. The construction is essentially jointless, strong and lightweight, and has planar or slightly curved sides forming a triangular or substantially triangular shape, so that the sides provide a large contact area for bearing against and securing to the walls of the container. Such tubular constructions may be inserted singly at corner edges, or applied along a wall between corner edges, or can be used singly or in multiples for central or other vertical reinforcement as well as transverse resistance to carton deformation. For most universal use, the tubular member is provided with a cross-section in the shape of a right isosceles triangle so that it not only fits within corner edges of rectangular boxes, but also provides a surface of relatively large area forming the hypotenuse for use against a flat surface to be reinforced, such as a wall between the corner edges of a container.

Two factors that affect the cubical rigidity, both axial and transverse, provided by reinforcement columns in a container are the surface area contact between the rein-

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forcing members and the walls of the container, and the distance that such contact extends from the corners. The greater the distance from the corner, the greater the moment of deformation resistance. In particular, a binding force is created by an adhesive or other bond established between the container and the amount of wall surface of the reinforcing member in frictional or adherent contact therewith that provides an integrated area factor affecting rigidity, and there is a moment arm factor due to the distance of the surface bonded from the corner as determined by the shape and dimensions of the reinforcing member. A tubular corner support of right triangular configuration has the advantage of occupying a minimum of usable central carton space, in a container having planar sides, in relation to the wall surface contact area and moment arm length established by mutual contact between the tubular member and the container walls. For example, a square cross section support with comparable corner contact surface occupies twice the usable carton area as a triangular cross section support, while cylindrical supports afford only line or tangential contact with the sides of a container. For a given central space sacrifice, the distance of such a tangential contact of a cylindrical support from the apex of the container corner is shorter than that of a triangular member and its integrated frictional force opposing transversing carton deformation is much smaller.

A further characteristic of the present tubular construction support of right isosceles triangular cross section is the somewhat greater degree of axial resilience afforded by the larger area of the hypotenuse side, as compared with a tubular construction support of square or circular cross section. It is believed that this resiliency may relieve momentary impact stresses that otherwise would cause failure in a more brittle construction.

Triangular or substantially triangular tubular supporting members embodying the present invention may be fabricated of axially oriented materials with fibres predominantly oriented in one direction. The member may be a resin moulding incorporating glass fibre reinforcement. Preferably however, a sheet of fabric of axially oriented material is rolled into a tubular shape, triangular in cross section, with the fibres of the material extending longitudinally and the layers are bonded together by means of an adhesive. High axial compressive or tensile resistance is obtained in the finished member from the inherent strength of the fibres in their lengthwise direction. Paper made by a cylinder machine, such as reprocessed kraft paper, has fibres predominantly oriented in what is known as the "machine direction" of the paper, i.e., the direction in which the web of paper is produced from the cylinder of the paper making machine. The compressive strength of such webs is substantially greater, in the "machine direction" than the cross machine direction. This difference is advantageously employed to fabricate triangular tubular constructions by convolutely winding the paper shapes in a direction across the machine direction of the paper. Such fibre orientation, coupled with the inherently good plybond characteristic of cylinder machine paper, results in a paper strength in the machine direction that may be two to four times greater than in the cross direction. Other fibre-like materials having appropriate length-to-cross sectional strength characteristics may offer strength advantages when used to construct triangular or substantially triangular tubular structures, but paper is advantageous because it has high strength, is relatively light, and is inexpensive.

A substantially triangular convex shape has the advantage over straight-sided structures of facilitating good adhesion and lamination while facilitating higher winding speeds by virtue of the slight wall curvature which tends to keep the sheet under tension during winding. At the same time, this shape maintains a relatively long moment arm and appreciable area contact as compared with a tube of circular cross section.

Two examples of supporting members constructed in accordance with the invention, and their use, are illustrated in the accompanying drawings, in which:—

Figure 1 is a partial detailed perspective view of one supporting member;

Figure 2 is a partial detailed perspective view of another supporting member;

Figure 3 is a partial perspective view of the member of Figure 1 positioned in a corner of a container;

Figure 4 is a partial plan view on an enlarged scale of the member and container of Figure 3;

Figure 5 is a partial perspective view of the member of Figure 2 positioned in the corner of a container;

Figure 6 is a partial plan view on an enlarged scale of the member and container of Figure 5; and,

Figure 7 is a plan view of a container reinforced with supporting members.

Figure 1 shows an elongated tubular member 10 of generally triangular cross section and including two flat side portions 12, 14 of equal dimensions in perpendicular planes, a third side portion or hypotenuse 16 connecting the side portions 12 and 14, and curved integral corner portions 18, 20, 22 at the junctures of the three side portions. In cross section, then, the member 10 is in the shape of a right-isosceles triangle with

rounded corners. The rounded corner portions 18, 20, 22 avoid weakening the tubular member at the junctures of the flat sides, facilitate the forming of the member 10, which may be accomplished by rapidly winding sheeet of material about a triangular-shaped mandrel, and facilitate close contact and a good bond between the windings at the corners. To assure these advantages, the corner portions 18, 20, 22 should preferably have a radius of curvature at least one-tenth the distance between the corner portions 20, 22, adjacent the longest side portion 16 when the member is fabricated by winding paper or the like about a mandrel. By way of illustration, the radius of curvature of the corner portions 18, 20, 22 of a generally triangular-shaped tube convolutely wound of paper is at least one quarter inch when the distance between the corner portions 20, 22 measured along the inner surface of the side portion 16 is two and one-half inches. By way of example only, a typical member convolutely wound of kraft paper and suitable for use as a container support column may have two flat sides of 2 1/4 inches in length joined at a corner by a curved portion of 3/8 inch radius, a hypotenuse side with a flat surface about 3 1/4 inches in length joined at corners to the other sides by curved portions of 3/8 inch radius, a total length of 60 inches, and a wall thickness of 3/8 inch.

The member 10 is composed of axially oriented sheet material having fibres of high compressive strength predominantly aligned longitudinally of the finished tubular member. When the sheet is wound into tubular form about a mandrel, rounded mandrel corners facilitate the attainment of better between-ply lamination and prevent creasing and weakening of the material, which could occur if the corners of the mandrel had sharp angles. As a result, it is possible to use material of lower tensile strength and wind at higher speeds without weakening the material. For added strength, the fibre material layers are bonded together with adhesive and/or impregnated with a hardening material, such as an adhesive or resin. In the embodiment shown, the support member 10 is formed of paper, such as reprocessed kraft paper formed on cylinder machines. This is low in cost and has fibres that extend predominantly in one direction, which corresponds to the longitudinal extent of the web of paper as formed and which is referred to as the "machine direction" of the paper. The paper is in a single sheet, or a lamination of multiple plies, or more than a single sheet, coated with an air drying adhesive or chemically linking thermoplastic or thermosetting resin and is convolutely wound to provide a plurality of layers, typically 8 to 11 layers in one preferred embodiment. The outer end of the sheet is shown at 26 and the inner end at 28. The paper is wound across the machine direction so that the fibres of the paper extend predominantly along the length of the member. In the preferred embodiment at least the outer end of the sheet forming the member 10 is skived, i.e., tapered in thickness, and is quite flexible, allowing it to lie flat against the underlying layers until the adhesive sets. This facilitates manufacture and permits the use of thicker paper which otherwise could not conveniently be used because the end of the sheet would spring up from the wound member. The thicker paper facilitated by the skived end permits a strong tubular member to be wound with fewer windings, increasing the speed of production and reducing costs.

The member 10 as shown in Figure 1 may be manufactured by winding sheet material on an elongated mandrel. Most advantageously the member is wound initially to a triangular shape, which is more difficult than winding a cylinder, but which provides a much stronger support than one which is shaped after winding. The sheet material to be wound is as wide as the desired length of the member 10 and is convolutely wound under tension upon the mandrel. The inner end 28 is placed on the mandrel and the mandrel is rotated about its longitudinal axis. A number of layers are wound (depending upon the thickness and strength of the material and the ultimate strength desired in the finished product) and the outer end 26 is adhered in place. Alternatively, a continuous web can be used and cut when the member has the required thickness. However, in forming the preferred embodiment from commercially available kraft paper manufactured on cylinder paper machines, a sheet of paper must be cut from the web or roll of paper, as supplied, to the length of the support desired. While this is inconvenient, it permits winding the paper transversely to the machine direction, which is along the web, resulting in a tubular member having superior strength over a member wound directly from a web. The cut sheet material is coated with an adhesive and then wound in the direction across the web. If the sheet material is pre-coated or already impregnated with an adhesive, the coating step is omitted.

A modified form of the generally triangular-shaped structure of Figure 1 is shown in Figure 2 and indicated generally by reference numeral 10′. The tubular structure 10′ is generally triangular in cross section but otherwise of identical construction to the member 10 and corresponding parts are identified with similar reference numerals with a prime designation. The structure is substantially triangular in that the side por-

tions 12′, 14′, 16′ are slightly curved rather than straight, yet the structure is a three-sided member of generally right-triangular configuraion constructed to fit within a corner of a rectangular box. The slight convex curvature, as shown, facilitates convolutely winding the structure from sheet material at a rapid rate while constantly maintaining a tension on the material. It will be appreciated that a substantially triangular shape wih slightly concave sides can be formed by winding a triangular tube and post-forming it. Good corner bearing moments can be attained with such a shape, but fabrication is more complex.

With a structure having flat sides, the tension on the sheet material being wound is maintained by the pull exerted through contact at each corner of the winding mandrel or preceding layer since, theoretically at least, there is no contact between the sheet material and the flat side until rotation brings the next adjacent corner into contact with the maerial, at which time that corner then exerts a tension or pulling force due to its effective lever arm length from the central axis of the winding mandrel. Thus, there is relatively little force urging adjacent layers into intimate contact along the flat sides of the structure and the rate at which the rotating mandrel, conventionally driven at a constant angular speed, demands sheet material is extremely non-uniform making it difficult to maintain winding tension as material is placed on the flat sides. The slight convex curvature of the sides 12′, 14′, 16′ causes the location that exerts tension on the sheet material as the structure is wound to progressively move from each successive corner across a side of the structure to the next corner in a rolling action. This not only makes higher winding speeds and more uniform tension possible by creating a more uniform demand for sheet material during winding, it also assures that each layer will be pressed against the preceding layer at all points about the periphery of the structure. At the same time, as long as the radius of curvature is maintained relatively large, e.g., at least as great as the distance from corner portion to corner portion of the respective side portion, the area contact and distance of such contact from a corner of a container will remain relatively large as will be described subsequently in connection with Figures 2 and 6.

The tubular structures 10 and 10′ are advantageously used to reinforce rectangular cardboard containers to increase the cubical rigidity and to bear the compressive load when the containers are stacked. Figures 3 to 6 illustrate the manner in which these structures are secured in each corner of a container to provide large area contact with the container wall and long moment arms while occupying only a small part of the internal volume of the container.

A partial, corner portion, of a box-type container 35 is shown in Figures 3 and 4, for example a corrugated cardboard box or carton. Two side walls 36, 38 are mutually perpendicular with a bottom 40 and top (not shown). The tubular member 10 of a length essentially equal to the height of the side walls 36, 38 is located at the juncture of walls 36, 38 and abuts the bottom 40. Side portion 12 of the member 10 is against side wall 38 and side portion 14 is against side wall 36 and are adhered over the contacting area, as by a suitable adhesive indicated at 41. Alternatively, staples or other fastening means can be used to attach the member to the side walls. The area of surface contact of both side portions 12, 14 extends along the entire height of the tubular member and along the entire width of each side portion, as indicated at *a* in connection with side portion 14. The length of the moment arm that resists distortion of the mutually perpendicular relationship of the container walls 36, 38 and bottom 40 is represented by *d*, which is the distance along the walls 36, 38 from their juncture to the farthest point of adherence between the respective wall and the reinforcing member 10. The distances *a* and *d* are about equal in the member 10 and, except for the rounded corner portions 18, 20, 22, have been maximized by the substantially triangular cross sectional shape of the tubular member with respect to the volume occupied and the periphery of the member. Because the cubical rigidity is a direct function of the integrated moments of the resistance, which is the summation of the products of the distances on the support from the carton wall intercepts and the adhesive strength per unit area, maximum transverse reinforcement is achieved with the substantially triangular-shaped tubular member 10′.

The same box 35 is shown in Figures 5 and 6 with the substantially triangular-shaped tubular member 10′.

The same box 35 is shown in Figures 5 and 6 with the substantially triangular-shaped tubular member 10′ located at the juncture of walls 36, 38. Because of the slight curvature of the side portions 12′, 14′, the contact area between the member 10′ and the container walls 36, 38 is somewhat less than that between the walls and the member 10, as indicated by the shorter length *d′* in Figures 5 and 6. A substantial area of mutual contact is created, notwithstanding the curved side portions 12′, 14′ by distortion of the container wall portions that abut the member 10′. As compared with a flat-sided member 10, some area contact is lost adjacent the corner portions 18′, 20′, 22′ due to the curvature of the side por-

tions 12′, 14′, yet the contact area is adequate to assure a strong bond as with an adhesive 41′. The curvature of the side portions 12′, 14′ has a lesser effect upon the effective moment arm length d' of the member 10′ because the length of the moment arm is diminished only by the decreased contact adjacent the corner portions 20′, 22′ and not by the decreased contact adjacent the juncture of the container walls 36, 38. As compared with a tubular member of cylindrical cross-sectional shape of similar perimeter or area, this substantially triangular construction 10′ provides substantially increased contact area and effective moment arm length, yet occupies less usable space in the container. At the same time, it facilitates rapid winding when fabricated from sheet material. Moreover, the effective moment arms of the substantially triangular-shaped member can be increased either by effective cementing with a self-adhering filling adhesive, or by stapling or mechanically attaching the support to the container wall at points beyond the closest contact of the curved side of the support, i.e. further away from the apex of the triangular member. It will be apparent that a substantially triangular-shaped member having slightly concave sides will have somewhat less area contact with the container walls than a triangular member but will maintain a maximum moment arm length.

Another manner in which tubular members 10 can be used to reinforce a container is shown in Figure 7 in conjunction with a box with a base or bottom wall 46 and perpendicular side walls 44. Four members 10 are located at the inside corners formed by the side walls 44 and four additional members are located one adjacent each wall 44 intermediate the corners. For optimum strength, the longest side wall 16 of each of the four additional members 10 bears against the associated side wall of the box to maximise the area of mutual contact. In addition, the smallest dimension, i.e., the altitude or distance of the triangular-shaped cross section from the wall 16 to the corner portion 18, extends inwardly and thus the usable space of the container occupied by the member is kept small. The four additional members can also afford protection to many objects inside the container by acting as a "stand-off" or cushioning spacer between the object and the carton wall.

WHAT WE CLAIM IS:—

1. An elongate stiff tubular supporting member having a unitary wall including at least one layer of material extending jointlessly around its whole periphery, the wall being substantially triangular in cross section and incorporating elongate strength-giving components aligned predominantly longitudinally of the member.

2. A member according to claim 1, which is formed of rolled sheet material incorporating fibres which extend predominantly axially of the member, and an adhesive bonding the layers of the sheet material together.

3. A member according to claim 2, wherein the sheet material is reprocessed cylinder-machine kraft paper oriented with the machine direction of the paper extending parallel to the longitudinal axis of the member.

4. A member according to any one of the preceding claims, wherein the corners of the triangular cross section are rounded and the distance between two adjacent corners is no more than ten times the radius of a corner.

5. A member according to any one of the preceding claims, in which a cross section of the member is substantially a right isosceles triangle.

6. A member according to any one of the preceding claims, the sides of which are curved transversely of their length.

7. A member according to claim 6, in which the sides are convex.

8. A member according to claim 1, substantially as described with reference to Figures 1, 3 and 4, or to Figures 2, 5 and 6, of the accompanying drawings.

9. A box-like container having at least one corner edge reinforced by a member according to any one of the preceding claims, the member having two of its sides in intimate contact with and secured to inside surfaces of the two container walls meeting at the corner edge.

10. A container according to claim 9, which has a further reinforcing member located with one side against and secured to a wall of the container between but parallel to two corner edges.

11. A container according to claim 9, substantially as described with reference to the accompanying drawings.

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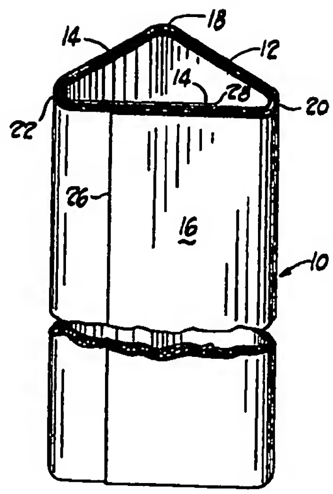

Fig. 1

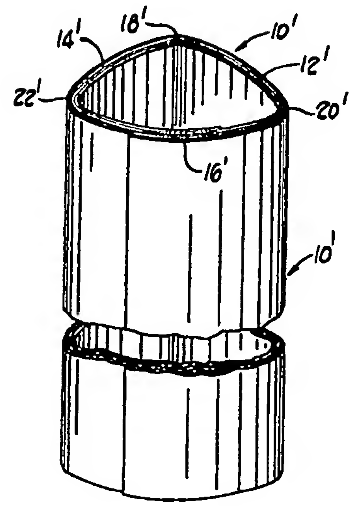

Fig. 2

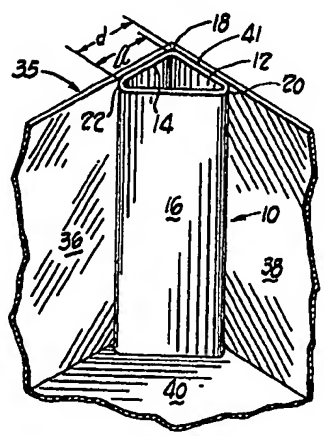

Fig. 3

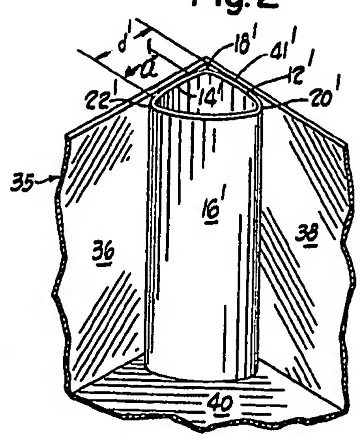

Fig. 5

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Sheet 2

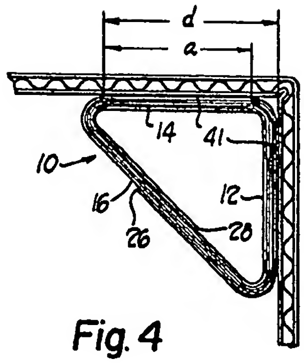

Fig. 4

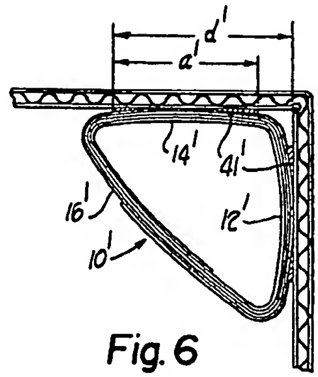

Fig. 6

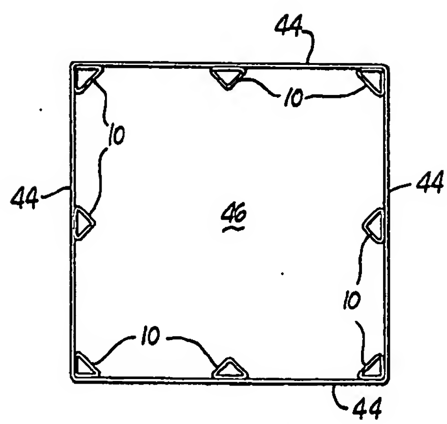

Fig. 7